Physicality, rationality and imagination

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Abstract

This paper describes an ongoing exploration examining the way different aspects of our cognition and physical interactions with the world work together. This will draw on material from several disciplines and will include some well established and some more speculative results. In the talk I'll also discuss how this understanding can influence design both because we can understand users better, but also because we can understand designers!

Keywords: interface design, evolutionary psychology, imagination, creativity, play

An exploration

This paper is not presenting a finished piece of work or even a definitive review of an area. Instead I am going to describe an exploration, a journey through a partially formed, partially understood intellectual territory. And, although distorted by the pressures of performance indicators, funding deadlines and publication targets, surely exploration is what academia is about?

We are going to look at two sides to human nature. On the one hand are the deep, usually unconscious and sometimes automatic responses and on the other are the conscious and complex ways in which we reason and imagine.

The deeper parts of our nature are often aspects that we share with animals and are either with us since birth or come, as a form of birthright, through being human in a human society and a physical world. In this I include not just very low level reactions to pain, and Skinner-style behavioural conditioning, but also those aspects of our cognitive nature that work without conscious attention and effort including basic number sense, and physical and social models of the world.

I've been struggling with a word to refer collectively to these deep responses and cognition as the words used in psychology tend to have very specific meanings. I often find myself using the term 'innate' although these things are clearly not all 'from birth'. I know this word is a term of debate in cognitive science so I apologise, but other words such as 'unconscious' or 'subliminal' (used in media studies for this) are equally problematic.

This distinction is important, not because it corresponds to a particular separation within the mind, but because it has practical implications for interfaces and design in general.

The deep 'innate' unconscious understanding we have of the world is only really good at dealing with the mundane, ordinary things of life, and is slow to adapt. Yet it requires little attention and mental effort (often indeed acting at a motor level) and is fast. In contrast our rich conscious thinking is highly effective for complex situations and can adapt to novel and changing circumstances. However, it needs attention and is comparatively slow.

If we can design devices well for the former we can harness its speed and low demands for low-level interaction and thus free our higher abilities for the real tasks we want to do.

Actually this is true at two levels. I have what I call the 'Golden Rule of Design':

understand your materials

For human–computer interaction this includes understanding humans and how their minds work. However, as designers and as academics we ourselves are also part of our own materials that we use during our creative work. By understanding better the way our minds work we are better able to utilise ourselves.

This issue of creativity is quite central. When referring to the higher more complex levels of thinking, I do not just refer to the classical Aristotelian logical thinking, but also the way in which imagination works with this and our deeper understandings.

From birth and before

The tiniest baby will curl its toes when its foot is stroked, will cry if stabbed with a needle to draw blood, or startle at a loud noise. These are clearly reactions hard wired into our nervous systems in the womb. However, there are also surprisingly complex cognitive processes that are present from birth or a very early age before they can have been learnt from the environment.

From the moment a child opens its eyes it is able to apprehend numbers up to three (Antell and Keating, 1983). This is detected using gaze length. On average a baby gazes longer at novel stimuli. If shown many different images all with two items the baby's gaze length will diminish gradually, but if an image with three items is introduced into the sequence, gaze length will increase. This is not just the complexity of the image gaining more attention; if images with three dots continue to be displayed the gaze again decays, but lengthens again if an image with two dots is shown. The baby has a sense of numerosity even at birth – really innate.

In fact other animals have this ability and in "The Number Sense" Dehaene suggests that there is a very old brain mechanism for recognising continuous number quantity with an error of around 20% (Dehaene, 1997). So, at a glance, we can tell the difference between 60 and 100, but not between 90 and 100 unless there is some special pattern. The difference between 2 and 3 is bigger than this 20% error hence the numbers 1, 2, 3 are all distinguishable uniquely.

As the baby grows to 5 months or so, similar experiments show that babies can effectively ‘add’ small numbers: if you put two things one by one behind a screen they ‘know’ that there should be 2 items there when the screen is removed (Wynne, 1992).

These abilities are distinct from ‘counting’ which is essentially a verbal related ability and comes much later.

As we grow we begin to become aware of our bodies, interact with our parents and family, and explore the world. This leads us into a range of abilities and understandings of the world. For example, when pressing a light switch or clicking a hypertext link, if there is no immediate reaction, the ‘instinctive’ response is to press again. Of course real physical things such as stones work exactly like that. If you push and it doesn’t move you simply press harder. Whether this is really an instinctive reaction, or merely one that has been learnt from an early age, it has certainly become part of our unconscious model of the physical world.

Where designs for systems work with this they work well. However, many computer and electronic systems do not work with these natural reactions. You press the ‘open/close door’ button, there is some delay in response and the door does not open, you press again, the system interprets your second press as a ‘close’ and hence the door starts to open and then instantly closes again.

Working with Masitah Ghazali at Lancaster, we have been looking at ordinary consumer devices and using them to uncover the ways in which their designers have (or have not) made use of natural properties of physicality (Ghazali and Dix, 2003). For example, some switches in and of themselves show that they have two states, on and off, whereas others require separate indicators. The former in some way embody natural properties of physicality. Similarly if we move a real thing by accident we simply move it back. Some devices make physically opposite actions have logically opposite effects. By studying these devices we aim to ‘mine’ the rich knowledge embodied within them, and hence build a design vocabulary and understanding that can be used for novel tangible devices.

In related work I have been looking at the way we have learnt to ‘grow’ our idea of ‘self’ to include artefacts around us (Dix, 2002). This is crucial for our understanding of cyborg technology and wearable computing. In everyday acts from driving a car to eating with knife and fork we are able to operate as if these things were in some way extensions to our bodies. In trying to understand this we can look back to tool use, both of early hominids and of other animals such as chimpanzees who use termite sticks to eat insects, and birds that crack snail shells with stones. In these cases too the animal needs, in some way, to operate as if the object were part of itself. Furthermore, using a stick means that the locus of action (the end of the stick in the hole) is distant from the locus of control (where the chimp holds the stick) – mediated hand-eye coordination not so far distant from moving a mouse cursor on the screen.

The many minds of the caveman

This reasoning forward from the behaviour of our ancestors to understand the modern mind, is something I recall doing as a school child. However, it was less than 10 years ago when I first used it 'in anger' in interaction problems, in particular to help understand why we appear not to be able to cope with rhythms slower than around a beat per second and are even less able to proceduralise any sort of delay (Dix, 1996).

The traditional maxim denoting a simple thing is to say "A child should be able to use it". For computer systems this was obviously silly ... it is the adults who have problems! Instead I coined my own maxim:

a caveman should be able to use it

By this I do not mean that a computer system should be usable by a re-animated Neolithic ice man, but instead that our brains and bodies are not substantially different from when we were hunter gatherers; there has simply not been sufficient time for natural selection to change us. So, if an interface requires any fundamental cognitive or physical abilities that a caveman would not need it is likely that we do not have them either. We are flexible and clever as users of course, so may well adapt, but it is likely to be hard to learn and potentially always require more mental effort and attention.

It was only around this time I found that there was a developing field of evolutionary psychology, notably Leda Cosmides and John Tooby at the University of California, Santa Barbara, looking at precisely this sort of reasoning (Tooby and Cosmides, 1997). Whilst this work has its critics there are few who would argue with the basic premise – we are all cavemen under our skulls!

Figure 1. is our mind like this?

One of the more controversial aspects of their work is the so called “Swiss Army Knife” model of the mind. Rather than seeing our reasoning as a generic tool influenced by experience and past inferences, they see it more as a collection of special purpose intelligences and reasoning units, each specialised for a particular domain: social, physical, animal, etc. An example of the latter is Cosmides experiments using variants of the Wason card test (Cosmides, 1989). If the task is posed as one of social contract and possible deceit the majority of people get the test ‘right’, whilst alternative ways to pose the question, even very concrete ones, all lead to ‘illogical’ answers.

Of course this ‘many intelligences’ is not controversial itself; most accept that we have some special purpose reasoning abilities. The differences are more about the details of these, the balance between general purpose intelligence and specialised intelligence and the level to which these are genetic or developed. From a design viewpoint, these special intelligences tend to be exactly the sort of deep, unconscious understanding that it is good to recruit in interfaces.

Mithin in his book “The Prehistory of the Mind” focuses on the way in which we link together these special purpose intelligences (Mithin, 1996). He looks to palaeontological evidence in order to try to discover when different kinds of intelligence became ‘joined up’. We seem to share many of these specialised intelligences with even primitive creatures, but for them they stay separate. He traces the way they start to join, leading to the point at about 40-60,000 years ago, when they eventually come together.

This socio-linguistic Eden (my term!) has been recognised as archaeologically significant for many reasons including the start of primitive art, changes in social patterns and the production of multi-part tools. Strangely there are no physiological changes at this time. The last significant changes in brain shape (as measured by skull shape) took place around 120,000 years ago. The spark at the Eden point seems to be more about language and social organisation than physical development, although clearly the cognitive and neurological foundations for this were laid some 80,000 years earlier.

Connections

Mithin’s work gives a clear story as to *when* our special purpose intelligences become ‘joined up’. I have become particularly interested in *how* they connect.

The most obvious way is through logical or formal reasoning. The knowledge from different sources is effectively encoded verbally or symbolically. The symbols are manipulated solely as symbols and because of their distancing from their real meanings are able to be processed uniformly. Whilst there has been a traditional fear in philosophy of the separation of words from deeper meanings (Tofts and McKeich, 1997), it is precisely this which makes them a tool for linking disparate understandings.

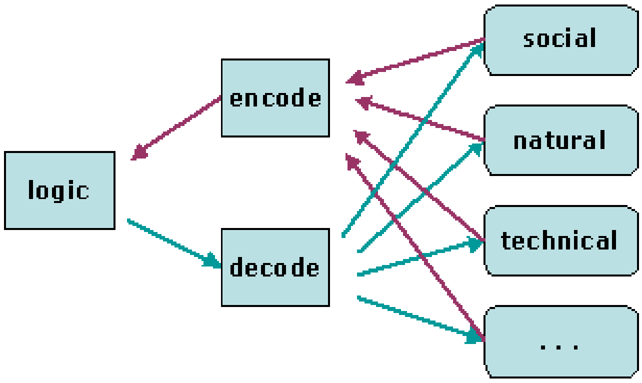

Figure 2. logic as the focus

However, there is also a form of linking that even the most primitive creatures possess. Because we live and act in the world our actions cause consequences that feed back through our perceptions. If my social sense tells me to go and talk to someone, the presence of a door in the way alerts my understanding of the physical world to open the door. The world 'kicks back', meaning that the actions of one type of intelligence create external causes for others.

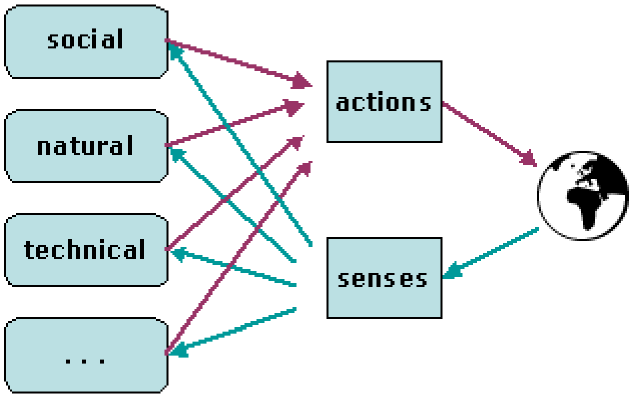

Figure 3. the world kicks back

Finally for now, although this is not the end of the story, our imaginations are very vivid. If a subject is brain scanned whilst looking at a picture various parts of the brain 'light up'. If the same person is asked to imagine the picture then many of the same areas light up including parts associated with perception right back to the visual cortex. It is really as if we perceive what we imagine. Because of this, our imaginings are 'available' to other parts of our minds just as real perceptions are. So when our social mind says "go talk to that person", we begin to imagine our getting up and going and this gets filled in by our spatial knowledge which mentally 'kicks back', when we imagine ourselves at the door.

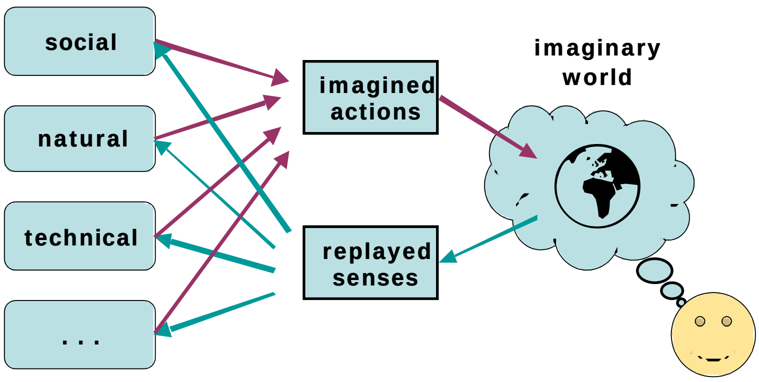

Figure 4. imagination kicks back

Of course, this is just the beginning. Our imagination and logic are not so disparate as they may seem. In fact, they do link together, notably through story and narrative; however, that is certainly another story! For more on this see my essays on imagination and rationality and related topics (Dix, 2003).

At a practical level we can harness these things.

This is one of the reasons that personae and scenarios are so useful in design. While we are talking about a user group, say warehouse managers, it is hard to know how they will behave, how they will react to particular designs. However, when we have a rich scenario like in figure 5, suddenly we are far more able to look at a design and say “Betty would do this there”. Our social understanding of others does not formalise well and so is hard to recruit logically when dealing with an abstract group. However, when faced with real situations and real people we are quite successful at predicting their actions and reactions. The scenario recruits the same understanding by summoning our imagination.

> Betty is 37 years old, She has been Warehouse Manager for five years and worked for Simpkins Brothers Engineering for twelve years. She didn’t go to university, but has studied in her evenings for a business diploma. She has two children aged 15 and 7 and does not like to work late. She did part of an introductory in-house computer course some years ago, but it was interrupted when she was promoted and could no longer afford to take the time. Her vision is perfect, but her right-hand movement is slightly restricted following an industrial accident 3 years ago. She is enthusiastic about her work and is happy to delegate responsibility and take suggestions from her staff. However, she does feel threatened by the introduction of yet another new computer system (the third in her time at SBE).

Figure 5. example scenario (from Dix et al., 2004)

The interplay between rationality and imagination is also something I use extensively in thinking about practical creativity and in the formulation of strategies and cognitive scaffolding for technical innovation (Dix, 1999). An example of this is the way in which we addressed the design of virtual Christmas crackers, taking a very physical and visceral experience and translating it onto the web (Dix, 2003b). The deconstruction–reconstruction process involves both rich imaginative understanding of the existing experience and also a reductionist dissection of the experience. *Together* these led to an innovative design that has elicited deep responses from those who remember childhood Christmases as well as fun for all!

Learning through play

Imagine a microbe 2 billion years ago. It has only one way to learn, through the patient and slow mutation of genes, through the death of those that take 'wrong' paths and life of those that succeed. Through countless generations they learn to adapt to their environment, passing on good traits to their offspring.

Now imagine a more complex creature, perhaps a small bird. Genetic evolution has endowed this creature with the ability to learn itself. It can adapt to certain changes in its environment: for example, some birds have learnt to place nuts on railway tracks so that they are crushed by the wheels and easier to eat. However, this knowledge is held only in the bird's own brain and is lost when it dies.

In fact, the bird's trick may well be picked up by others, because in packs, flocks and herds and also in family units we have also the ability to imitate. Imitation plus lifetime memory enables social animals to pass on knowledge. However, this can only happen when there is some level of shared experience. Without co-experience there can be no imitation and so no learning.

Play partially breaks this link, allowing young animals to engage in experiences that are not real. Through vicarious experience they learn about things they have never directly experienced. Of course this play is rooted in a degree of imagination, albeit primitive.

Finally it is through language that we are able to codify that vicarious experience into words that have life outside the individual.

In summary, we have a progression:

- evolution – learning across generations, very slow changes
- lifetime learning – learning within one individual, fast changes
- herd imitation – learning across generations, needs co-experience
- play – learning across generations, through vicarious experience and imagination
- language – learning across generations, through imagination and symbols

Note the way that play prefigures language and develops exactly the imaginative (re)creation of experience that will later be needed for narrative and story telling. Indeed in a recent book it is argued that one of the key things that makes us human is exactly that we never fully mature! (Bromhall, 2003)

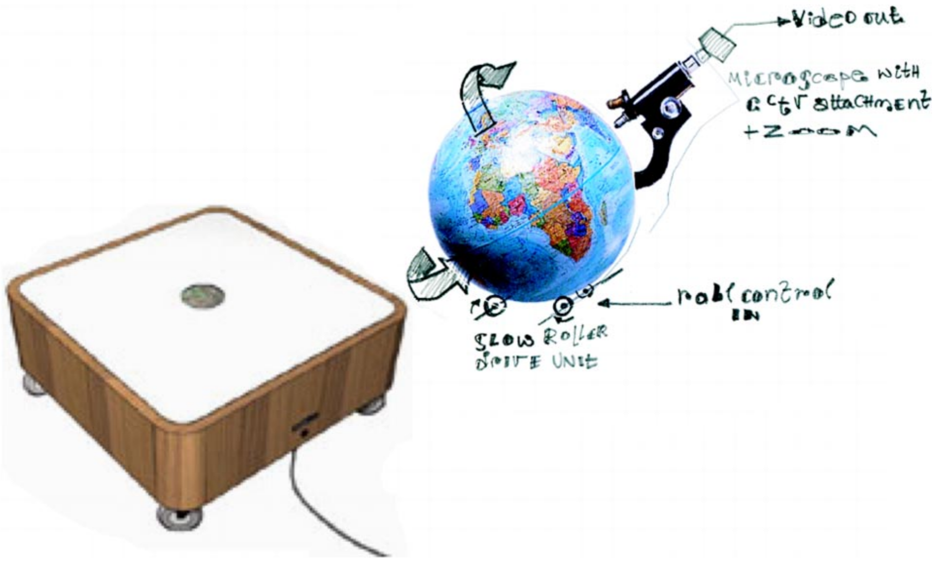

Figure 6. ludic design Gaver's drift table (Gaver, et al., 2003)

Again, we can make use of the power of playful imaginings in design. Bill Gaver has been a strong advocate of 'ludic' design, design for the playfulness of people's lives (Gaver, et al., 2003). Also play can be used as a design heuristic. I advocate the use of 'bad ideas' in design, to prompt radical steps in the design space and create 'safe' places for training critical skills (Dix, 1999).

In Lancaster Computing Department, we have a performance arts group called .:thePooch:. who create various installations often in 'playful arenas' such as clubs and arts events (www.thepooch.com). As well as being successful as art, these exhibits often create opportunities to see radically different kinds of interaction. For example, the Schizophrenic Cyborg consists of two performers. One wears a screen strapped to his stomach whilst the other at some distance has a laptop which wirelessly sends text to the screen. Those who interact with the cyborg have to cope with effectively two individuals in the 'same space'. Even if told that the screen is controlled elsewhere they find it hard to dissociate the two and the cyborg himself feels dislocated (Sheridan et al., 2004).

Figure 7. schizophrenic cyborg

Although this is an extreme example, we are all of us finding ourselves in multi-party multi-way interactions through phone, chat programs, and face to face conversations. As wearable technology becomes common it may not be easy to tell if a person is looking into your eyes or at the text scrolling projected onto her retina (Sheridan et al., 2000). The playfulness of the arts world allows us to experiment with aspects of interaction that would be hard to create now in ‘serious’ settings, yet are clearly going to become important in the future.

Beginnings

At this point it is customary to have a conclusion, but as this is an exploration and a journey, conclusions sound too tidied up, too final.

I hope I have given some inkling of the fascinating interplay between rationality, physicality and imagination. I also believe that some of the practical outcomes of this are evident both in terms of understanding the users of our designs and also understanding how we can better operate as designers and academics.

However, these are merely beginnings and I am very aware that this sort of work treads, sometimes roughshod, over many disciplines. I am therefore eager to receive feedback and hear of related work.

I will post further links and information at:

`http://www.hcibook.com/alan/papers/i2004-imagination/`

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